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(54) Electrical fuse

(57) An electrical fuse comprises a substrate (1) with a superimposed conducting layer (2) having a fusible portion (3) at a narrowing of the conductor width. The fusible portion is at least partially covered by a layer (4) of material capable of forming an alloy with the material of the conductor. A layer (6) of electrically insulating material is optionally present between layers 2 and 4. The speed with which the fuse reacts to an overcurrent can be controlled by varying the material, extent, and thickness of the covering layer.

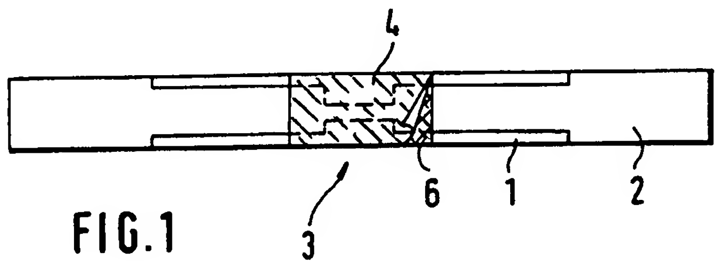

FIG.1

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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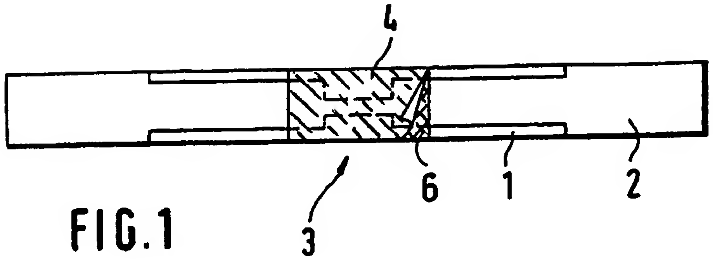


FIG.1

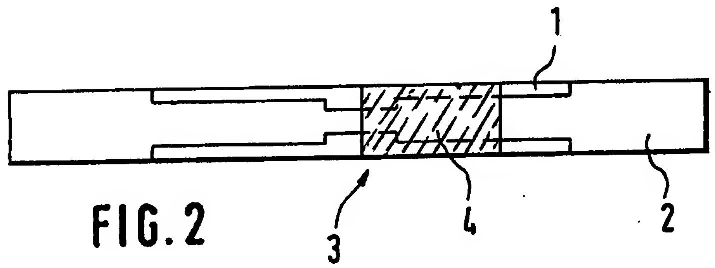


FIG.2

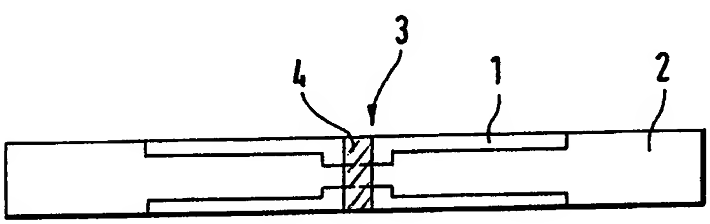
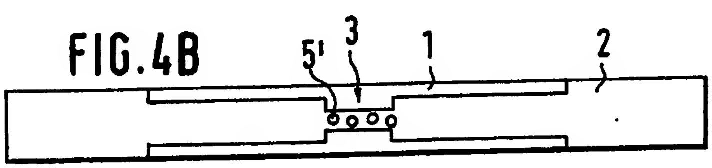


FIG.3

FIG.4B



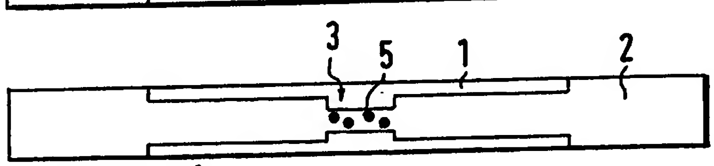


FIG.4A

SPECIFICATION

Electrical fuse

The invention refers to an electrical fuse comprising a substrate with a superimposed fusible conductor having a fusible portion at a narrowing of the conductor width. Such a fuse is hereinafter referred to as of the kind described.

Fuses of this kind have been known for a long time in various forms (e.g. West German O/S 1,588,333). What is common to them is that they all have a super-quick-acting characteristic which may only be influenced slightly by an alteration of the shape of the fusible portion.

As the fusible conductor either silver or low melting-point metals and alloys (West German P/S 744,200) are employed. When a coating of silver is used as the fusible conductor on the substrate the application of the coating by screen printing is known.

The possibilities for altering the super-quick-acting characteristic by means of a modified geometry of the fusible portion are only extremely limited, and only fuses with quick-acting characteristics can be produced in this way. Consequently the range of application of such fuses is severely restricted.

It is accordingly the object of the invention to modify a fuse of the kind described in such a way that it is available for wider ranges of application.

In accordance with the invention, it is proposed that the fusible portion be wholly or partially covered by a layer of material capable of forming an alloy with the material of the conductor.

In this way there may be imparted to the fuse a characteristic which lies within the spectrum from super-quick-acting down to slow-acting. For such adaptation the composition of the alloying material is primarily decisive, in that, as a fundamental rule, the fuse will be the slower-acting the more eager the material of the covering layer is to form an alloy, or the lower lies the overall temperature of fusion which is brought about because of the alloying. Furthermore, a particularly thick covering layer, because of the relatively large mass, contributes to a slow-acting behaviour.

The inertia or the quick-action of a fuse is judged according to the measured fusion time which is required for the melting through of the fusible portion at a certain overcurrent. For uniform standards of fuse characteristics, there is laid down in each case the fusion time which is reached at an overcurrent of ten times the normal current. In connection with an alloying fuse attention must be paid to the fact that the normal current, because of the alloying, is reduced and hence the theoretical testing current for the determination of the standardized fusion time also becomes smaller. Consequently the fuses in accordance with the invention with their covering layer of alloying material, always exhibit at the standardization point a greater inertia than fuses of the same shape without a covering layer.

Obviously a fuse in accordance with the invention responds also below and above the standardization point, that is, below and above an overcurrent of ten times the normal current, as long as the normal current is significantly exceeded. In these cases of loading which are not covered by the standard fuse, characteristics may be produced which are dependent upon the level of the overcurrents. If, e.g., only half of the length of fusible portion is covered across its full width by the cover layer, there results for low overcurrents a relatively high inertia, whilst at very high overcurrents a quick-acting characteristic prevails.

By means of the alloying material, its thickness and the degree of covering, an extraordinary multiplicity of characteristics can be chosen for the individual fuse duties so that the fuse in accordance with the invention may be used even when slow-acting, medium slow-acting or slow/quick-acting characteristics are necessary.

The covering of fusible portion by the cover layer does not always need to be effected, e.g., across the full width. Patterns of covering are likewise possible in which an uncovered path is left in the region of fusible portion. That may be effected by a cover layer consisting of island zones, or by a part covering over of fusible portion, e.g., one half of its length. Further variations may be provided as a result of the way in which the alloying material runs upon heating, prior to fusion so that either the whole width of fusible portion is covered or an uncovered path is left, particularly when the cover layer consists of island zones. Independently of the pattern of covering, the application of the alloy-forming cover layer may be effected by means of the screen printing process, but foils too may well be rolled on or applied in some other form.

For the cover layer the alloy SnPb, has proved a particularly eagerly alloying material, but even so pure tin is also very suitable, or other materials employed in soft-soldering. With a decreasing melting point of the alloying material which, upon alloying with fusible conductor, leads to a correspondingly sharp drop in its fusion temperature at the instant of the alloying, the inertia of the fuse also increases, in which case the thicknesses of both fusible conductor and the cover layer become further variable parameters. The thicker the two layers are, that is, the greater the mass which has to be melted, the slower acting the characteristic of the corresponding fuse is seen to be. For the variation of the thickness of layer both of the fusible conductor and also of the cover layer a range of between 0.2 and 100 μm, preferably between 30 and 40 μm, is particularly suitable.

After the expiry of a fairly long period of time after the production of the fuse it may happen that constituents of the alloying material, even without any operation of the fuse, enter prematurely into a combinaton with fusible conductor as a result of diffusion. It has already been observed that under the aforesaid circumstances tin from a tin-lead alloy has diffused into the uppermost part of fusible conductor of silver. This effect may arise during service and also in the case of currentless storage. For the avoidance of such aging, in further development of the invention it is provided that between the

fusible conductor and the cover layer ther is provided a film of electrically non-conductive fusible material.

It has been found that the film which consists, e.g., of commercial soldering varnish, melts upon operation of the fuse because of the raised temperature and directly thereafter contact takes place between the then already preheated alloying material and fusible conductor. In this way up to this instant contact between the two layers and thereby ageing is prevented and operation of the fuse is thereby not impaired. In the case of the employment of a film of a definite melting point, e.g., a varnish on a wax basis, the resistance to ageing is preserved until the fuse loading leads to heating such that the film melts.

Examples of fuses constructed in accordance with the invention are illustrated in the accompanying drawings, in which:-

Figure 1 is a plan of a first example having a completely fusible portion;

Figure 2 is a plan of a second example having a fusible portion covered across its full width and along half its length from one end;

Figure 3 is a plan of a third example having a fusible portion covered over its full width along the middle third of its length; and,

Figures 4A and *4B* are plans of further examples having a fusible portion covered with island zones leaving an uncovered path.

The illustrated examples of fuse have, in each case, as a carrier, a substrate 1 to which is applied fusible conductor layer 2. The substrate may consist of, e.g., an Al_2O_3 ceramic and fusible conductor a layer 2 of silver. The application of this layer to the substrate 1 may be carried out by gluing on a foil, but what is more economical is application by means of the screen printing process with subsequent burning of fusible conductor layer 2 into the substrate 1. The width of fusible conductor 2 is narrowed in about the middle for the formation of fusible portion 3, whereby the resistance of fusible conductor path is increased at this point. In the region of this point of fusion 3 there is effected the total or partial covering over of fusible conductor by means of a cover layer 4 capable of forming an alloy with fusible conductor material.

In the case of the example illustrated in Figure 1, the cover layer 4 covers over the fusible portion 3. This type of fuse exhibits a characteristic which is essentially the same for all overcurrents, in which case the degree of inertia or of quick-action depends primarily upon the choice of the alloying material for the cover layer. The more eager the material is to alloy and the lower its melting point, the slow-acting is the fuse.

If, e.g., a silver layer 25 μm thick of the geometrical form shown in accordance with Figure 1 is printed onto a substrate of Al_2O_3 ceramic and if no cover layer 4 of any kind is employed, at the point of standardization there results a fusion tim of only 0.2 ms. at an overcurrent of 31.5A. If this same silver layer is covered over with a cover layer of 0.1 mm. thickness of SnPb 40/60 having a melting point of 183°C through the relatively low melting point of the cover layer the formation of alloy is started at a very early point in time, so that the complete alloy of the cover layer and the silver layer exhibits a l wer melting point than the pure silver layer. This very rapidly arising complete alloying exhibits a lower normal current - one speaks here of a drop in normal current - so that in accordance with the definition of the point of standardization the theoretical testing current is seen to be less than ten times the normal current. Less energy is thereby available for the fusion of the fusion stage, so that the fusion time is prolonged. In the present case it amounts to 300 ms. at an overcurrent of 25A, in which case as compared with the example described above of a pure silver layer fuse the prolongation of the fusing time also proceeds from the mass which has to be melted, having been increased because of the cover layer. A reduction in the amount of solder accordingly leads to a fusion time of less than 300 ms. under otherwise unaltered conditions.

A further reduction in the fusion time results if, instead of the soft solder SnPb 40/60, e.g., pure tin is employed, the melting point of which lies at 326°C. Not only is the fusion temperature of the complete alloy which arises, thereby raised, by the eagerness for alloying tin is also less, so that the alloying starts more slowly. If the tin is applied in the same thickness of layer of 0.1 mm. as, in the case of the above example, the soft solder SnPb 40/60 was applied, the fusion time amounts to only 10 ms. at a theoretical testing current of 28A.

In the case of the Figure 2 example, only half of fusible portion 3 is covered by the cover layer 4. Within this covered region the full width of fusible portion 3 is overlaid. This type of fuse exhibits a characteristic which is dependent upon the level of the overcurrent. At low overcurrents there is a greater inertia than at very high overcurrents. The cause is that at very high currents the exposed part of the fusible portion 3 already reacts before significant alloying and thereby a traceable drop in normal current occurs.

In the case of a covering as in Figure 3, a characteristic is produced which approaches closely to a quick-acting one, that is, which settles down between quick-acting and quick/slow-acting. The drop in normal current which can be achieved in the case of this example may, because of the smaller area covered, only be very small, which is correspondingly reflected in the characteristic.

In the case of the aforesaid examples the cover layer 4 in each case covers the whole width of the fusible portion 3 even when only part of the length is covered over. Deviating from this, Figures 4A and 4B show a covering consisting of island zones 5 and 5', which may be circular, and which leads to the situation that apart from these zones an uncovered path remains for the current.

For the final determination of the characteristic the important thing is the size of the zones 5 and 5', although indirectly also the thickness of layer. That is, upon the response of the fuse to the heating, the alloy-forming material flows out of the originally narrowly limited zones 5 and 5', so that, depending upon the previously chosen spacing, the regions

which have then flowed apart touch one another or not.

In the case of the Figure 4A example the thickness of layer, the size of the zones 5 as well as their spacings are so chosen that even in the case of fuse response no running into one another of the zones takes place. Also the width of fusible portion 3 does not become completely covered at any instant. In the case of this fuse the characteristic is in the neighbourhood of super-quick-acting.

The characteristic of the fuse of the Figure 4B example will be rather slower-acting, since here the zones 5' are altogether larger and furthermore running into one another upon response of the fuse is intended. The uncovered current paths originally existing between the zones 5' thereby become closed, so that even in these regions alloying takes place, although it starts later.

In the case of all the examples an electrically non-conductive film 6 (Figure 1 under the raised cover layer 4) may be provided between fusible conductor 2 and the cover layer 4 for separation of the two layers from one another, which may be necessary for the prevention of ageing. In particular in the case of cover layers eager to form alloys, this measure may be necessary.

The cover layer may be applied in a thickness of 0.2 - 100 μm. Because of the mass of the cover layer introduced into the fusible portion, its thickness is a means of varying the fuse characteristic. In the case of a substrate of, e.g., Al_2O_3 ceramic at a commercially available thickness of 0.63 mm. and fusible conductor of silver of a thickness of 25 μm. there results, e.g., a quick-acting characteristic, if pure tin is applied as the cover layer in a thickness of 30 μm. whereas there results a slow-acting characteristic if the cover layer is applied with soft solder SnPb 40/60 of a thickness of 100 μm. It may be assumed that between the silver layer and the respective cover layer there exists a soldering varnish as a separating film.

CLAIMS

1. An electrical fuse comprising a substrate with a superimposed fusible conductor having a fusible portion at a narrowing of the conductor width, characterized in that the fusible portion is at least partially covered by a layer of material capable of forming an alloy with the material of the conductor.

2. A fuse according to claim 1, characterized in that the cover layer consists of a SnPb alloy.

3. A fuse according to claim 1 or claim 2, characterized in that between the fusible conductor and the cover layer there is provided a film of electrically non-conductive fusible material.

4. A fuse according to any one of the preceding claims, characterized in that the thicknesses of the fusible conductor and of the cover layer are each between 30 and 40 μm.

5. A fuse according to any one of the preceding claims, characterized in that fusible portion is covered over its full width and substantially halfway along by the cover layer.

6. A fuse according to any one of claims 1 to 4, characterized in that substantially the middle third of the length of the fusible portion is cov red ov r its full width by the cover layer.

7. A fuse according to any one of claims 1 to 4, characterized in that the fusible portion is covered over by island zones of the cover layer leaving an uncovered path along the fusible portion.

8. A duse according to claim 7, characterized in that the zones are circular.

9. A fuse according to claim 7 or claim 8, characterized in that the distance between the zones is so small that, in the event of fusion of the fusible portion, the zones flow into one another as a result of the heating.

10. A fuse according to claim 7 or claim 8, characterized in that the distance between the zones is so great that, in the event of fusion of the fusible portion, the zones remain separate from one another in spite of a certain flow resulting from the heating.

11. A fuse according to claim 1, substantially as described with reference to any one of the examples illustrated in the accompanying drawings.

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